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RECENT IMPLOSION EXPERIMENTS AT NOVA*

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Both electron (direct) and x-ray (indirect) driven implosions of DT targets have been done using ~20 kJ of 0.35 μm light from the ten beam Nova laser facility. The direct drive targets (glass microballoons with nominal dimensions of 1000 μm x 2 μm and DT pressures of 12-14 atm.) produced neutron yields in excess of 10^{13} and fusion efficiencies >0.15%. Implosion characteristics were low fuel areal density (<1 mg/cm^2) and high ion temperatures (~10 keV) in the imploded fuel. The first ablatively compressed, x-ray driven targets shot at Nova reached high confinement conditions ($n\tau \times \theta$ product of ~10^{14}). They produced neutron yields of 3-5 x 10^{10}, ion temperatures of 1-2 keV and areal densities estimated to be >10 mg/cm^2. Recent experiments will be described, with particular emphasis on measurements made using neutron diagnostics. We acknowledge the University of Rochester Laboratory for Laser Energetics for their contribution to the direct drive experiments and KMS Fusion for providing targets.

A primary goal of the Nova facility is to achieve high gain target conditions in a scaled implosion. Achieving this would not produce breakeven or gain due to insufficient target mass, but would result in high compression at a fuel ion temperature (θ_i) of about 3 keV. In an effort to reach this goal, initial implosion experiments on DT gas filled targets have begun. Both electron (direct) and x-ray (indirect) driven implosions have been done.

Direct drive targets were glass microballoons with nominal dimensions of 1000 μm diameter with 2 μm wall thickness and contained DT pressures of 12-14 atm. These targets were irradiated with the ten Nova beams at 2 kJ each for a total of 20 kJ of 0.35 μm light in a 1 ns square pulse. Targential focussing was used. Neutron yields (Y_n) of 1 x 10^{13} were typically obtained which corresponds to a fusion efficiency of $E_{fus}/E_{laser} = 0.15\%$.

Fuel ion temperatures (θ_i) were measured on two shots using a neutron time-of-flight system (i.e., see Ref. 1) with a ~20 m flight path. Due to the large size of the Nova chamber (4.6 m diameter) and the use of a hole in the concrete target room wall as a collimator, the scattered neutron background is quite low. Figure 1 shows a sample oscilloscope trace for a θ_i measurement. θ_i values of 10.6 ± 1.5 and 7.8 ± 1.5 keV were measured for the two shots.

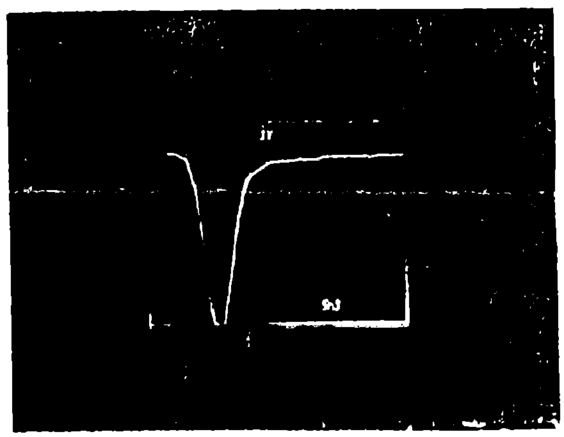

Fig. 1: Sample oscilloscope trace for θ_i measurement. Flight path was 19.8 m; observed θ_i was 7.8 ± 1.5 keV.

Fuel areal densities (<ρR>) were measured using CR-39 track detectors to observe neutron scattered D and T ("knock-ons").[2] <ρR> values of < 1 mg/cm^2 were observed. <ρR>, Y_n, and θ_i are consistent with a simple model of a uniform temperature and density burn confined for a time limited by fuel disassembly at sound speed.

Indirect drive targets were ablatively compressed to higher densities with lower fuel ion temperatures. Neutron yields of 3×10^{10} and 5×10^{10} were measured for two shots. θ_i values of 1.7 ± 0.3 keV were measured for both shots. Assuming fuel disassembly time limited by sound speed and a uniform temperature and density burn, these values of Y_n and θ_i lead to an estimate of $\langle\rho R\rangle > 10$ mg/cm^2. This value of $\langle\rho R\rangle$ corresponds to a density of 30-40 times liquid.

Diagnostic techniques to better characterize these implosions are under development, with particular emphasis on a technique to measure fuel $\langle\rho R\rangle$ for high compression targets. Measurement of DT neutrons produced from DD fuel is a prime candidate for this.[3,4] Future experiments will use cryogenic targets and laser pulse shaping as methods to achieve higher compressions.

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